national accelerator laboratory

FN-204
2250

RATIONALE FOR A CHOICE OF SECONDARY PARTICLE BEAMS AT NAL

A. L. Read and J. K. Walker

February 1970

ABSTRACT

In this note we discuss choices and priorities for the first and second rounds of secondary particle beams and research facilities at NAL.

I. INTRODUCTION

In this note we discuss the plans which are developing in the Experimental-Facilities Section for the design and construction of the various secondary beam lines. In particular, we concentrate upon the factors which determine the priorities and construction schedules for the different beams. Underlying the plans we describe here is an important philosophical ingredient: namely, that in the first few beams to be built and operated, we want to emphasize the full variety of beam facilities as early as practicable in the research program at the NAL accelerator. Thus, in the first round of beams that are to be set up, we are advocating the installation of one of each of four quite different kinds of secondary beam, rather than emphasizing a more intensive initial coverage of one particular facet of the research program.

II. SECONDARY BEAMS WHICH HAVE HIGH PRIORITY

There are six different kinds of beam which we believe to be most important. These are

1. A high-energy hadron beam ($\pi^{\pm}$, $K^{\pm}$, $\bar{p}$), covering the entire energy range for hadron physics up to 200 GeV.

2. An intense, high-energy beam of neutrinos, for the study of weak interactions at high-energy loss and high-momentum transfer.

3. A large-acceptance, high-intensity pion beam for the measurement of small cross sections and for production of special tertiary beams--electrons, photons, K^{0}'s.

4. A small angle ($\approx 0^\circ$) beam for 200-GeV proton experiments, such as production of neutral and charged hyperons, K^0's and neutrons. In addition, it would be possible to perform "thin target" and beam-dump experiments.

5. An rf-separated beam to obtain separated or enriched beams of relatively rare particles such as $K^\pm$ and $\overline{p}$ for bubble-chamber studies and special studies with counter arrangements.

6. A high-energy μ beam to extend the study of electromagnetic interactions to high energies and high momentum transfers (there being no competitive electron accelerator in the energy region above 25 GeV).

We note that an initial μ beam at NAL can be extracted from the end of the neutrino decay tunnel at relatively modest cost. A unique feature of this μ beam is its controlled and high degree of polarization. For simplicity we identify the μ beam as part of the neutrino facility.

The separated beam is intended for both counter work and for bubble-chamber exposures. The rf beam is extremely long and therefore expensive, and the development of cw cavities for counter work is still in a primitive state. Furthermore, it is possible to transport an unseparated high-energy hadron beam to a bubble chamber through the above muon beam transport system. This would provide for bubble-chamber exposures to π^- and proton beams up to 200 GeV in addition to the studies of neutrino and muon interactions in the first phase of the experimental program. Also, it may be possible to identify the hadrons (in particular for π^+-p separation) with a Čerenkov counter and thereby tag their interactions in the bubble chamber. For these reasons, we prefer not to emphasize the rf beam in the initial set of beam priorities as much as we emphasize the other four beams.

The four high-priority beams are

1. High-energy hadrons
2. Neutrino/ μ's
3. High-intensity beam
4. 200-GeV attenuated proton beam facility.

The four high-priority beams discussed above will provide us the ability to perform a well-balanced initial research program in Experimental Areas 1 and 2. The neutrino/ μ beam would be located in Area 1; the high-energy hadron beam, the 200-BeV attenuated proton beam facility, and the high-intensity beam would be located in Area 2.

III. FIRST AND SECOND PHASES OF EXPERIMENTAL PROGRAM DEVELOPMENT

In the first round of experiments at NAL, we would expect that the four beams discussed in Section II would be installed and that rather modest experimental arrangements would be used initially for physics experiments ("modular" detector arrays).

In the second phase of the experimental program, three roughly parallel activities (A, B, and C, described below) are anticipated:

A. The Construction of More Secondary Beams in Areas 1 and 2

These can be divided into three distinct categories:

1. The rf-beam facility
2. Branches in existing secondary beams
3. Additional secondary beams of hadrons in Areas 1 and 2.

The RF-Beam Facility

A multi-phased approach to the development and use of the rf-beam facility seems likely. A possible sequence might be as follows:

1. Unseparated use of the beam-line
2. S-band pulsed cavities for low-energy (30-50 GeV) K beam for bubble chamber
3. X-band pulsed cavities for high energy (up to ~100 GeV) K-beam for bubble chamber
4. CW cavities, for provision of long-spill separated beams for counter experiments.

Branches in Existing Beams

Branches in some or all of the four high-priority beams may be built as follows:

1. A Y in the high-energy unseparated hadron beam
2. A Y in the 200-BeV proton-beam facility to enable simultaneous setup of a short-lived beam experiment and a proton-scattering experiment
3. Completion of the "tertiary" beam stage of the high-intensity π beam (to make μ, e, γ, K^0, etc.)

4. A Y in the μ channel of the ν/μ beam to transport muons to an additional experimental area. Also, the installation of slits, special target, etc., to transport unseparated hadrons to a bubble chamber.

Additional Secondary Beams

These include the following possibilities:

1. Medium-energy (~75 GeV) moderate-resolution hadron beam (and branch)

2. Parasitic beams.

B. The Completion and Initial Operation of Spectrometer Facilities in the Four High-Priority Beams

These might include a large-mass ν- and μ-interaction spectrometer, a bubble chamber, a modular large-aperture spectrometer, a high-energy high-resolution spectrometer, and a special spectrometer for short-lived particle studies. In each case we anticipate three stages of development:

1. the initial, modest "modular" array

2. a spectrometer facility

3. additions to the spectrometer facility and provision of additional detectors, so that, on the average, there would be two experimental setups along each secondary beam line.

C. The Completion of Construction of the Third Experimental Area

IV. THIRD PHASE OF EXPERIMENTAL PROGRAM DEVELOPMENT

Further development of the experimental facilities will involve an increase in depth of the research program in Areas 1 and 2 and simultaneously the implementation of new beams (with maximum momentum capabilities of ~ 500 GeV) in Area 3. This will be done up to the planned scope of the research facilities which has been defined in the NAL 1968 Design Report. At the present time we do not identify any particular characteristics of the beams in the third area. However, we anticipate that the choice of beams in Area 3 will in part be influenced by the results of research in Areas 1 and 2. Therefore, the maintenance of flexibility for the design of Area 3 is mandatory.

VI. SUMMARY OF THE BEAM DISCUSSIONS

The above lists of beams, spectrometers, and their relative construction priorities are summarized in Table I and shown schematically in Fig. 1.

We believe that the brief arguments presented above can serve as a useful basis for discussion and decision on research program plans by the Director of the Laboratory and his various groups of staff and visiting advisors.

ACKNOWLEDGMENTS

We wish to acknowledge the contributions to these ideas by T. Yamanouchi, J. Lach, F. Nezrick, R. Carrigan, J. R. Sanford, T. Collins, W. Baker and E. Bleser.

Table I.

Phase 1

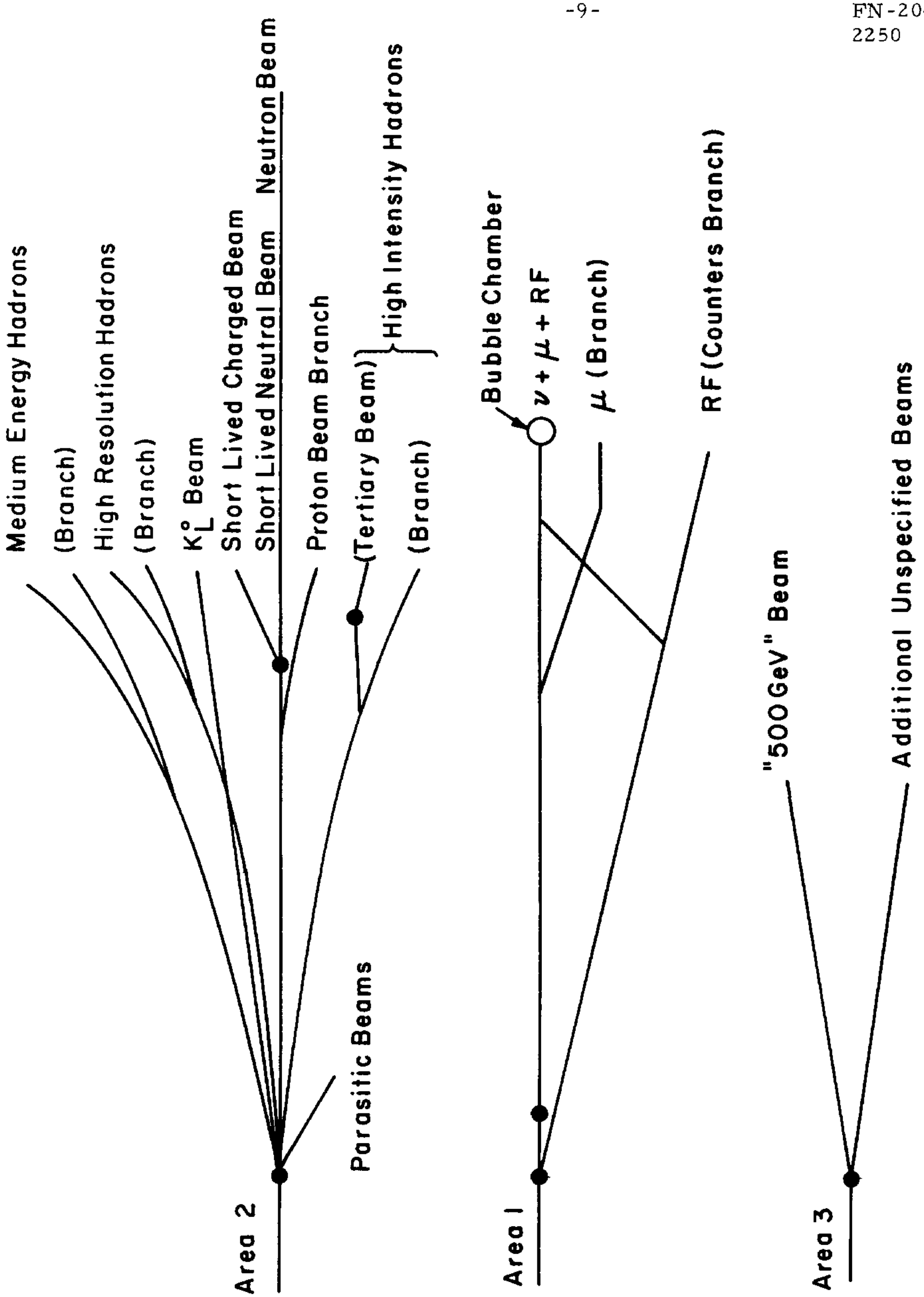
	Beam Title	Area	Basic Detector
1.	High-energy, high-resolution hadron beam	2	High-resolution, high-energy spectrometer facility
2.	Neutrino plus polarized muon beam	1	Lepton counter facility and bubble chamber
3.	High-intensity, medium-resolution hadron beam	2	Large aperture modular spectrometer facility
4.	200-BeV proton-beam facility	2	Short-lived beam spectrometer facility

Phase 2

Parallel development of the following:

1. Area 3 construction completed
2. Further development of the above "basic detectors"
3. Completion of bubble-chamber construction
4. Further beams in Areas 1 and 2 itemized below

	Beam Description	Area
1.	Hadron beam through the μ transport system to the bubble chamber	1
2.	Branch on the muon beam	1
3.	Branch on high-resolution beam	2
4.	Branch on proton beam facility	2
5.	Tertiary beam development on the high-intensity beam	2
6.	RF beam phased development begins	1
7.	Medium-energy beam	2
	Phase 3	
8.	"500-GeV" hadron beam	3
9.	Implementation of new facilities suggested by the research results in Areas 1 and 2.	1, 2, 3



Schematic Arrangement of Secondary Beams

Fig. 1